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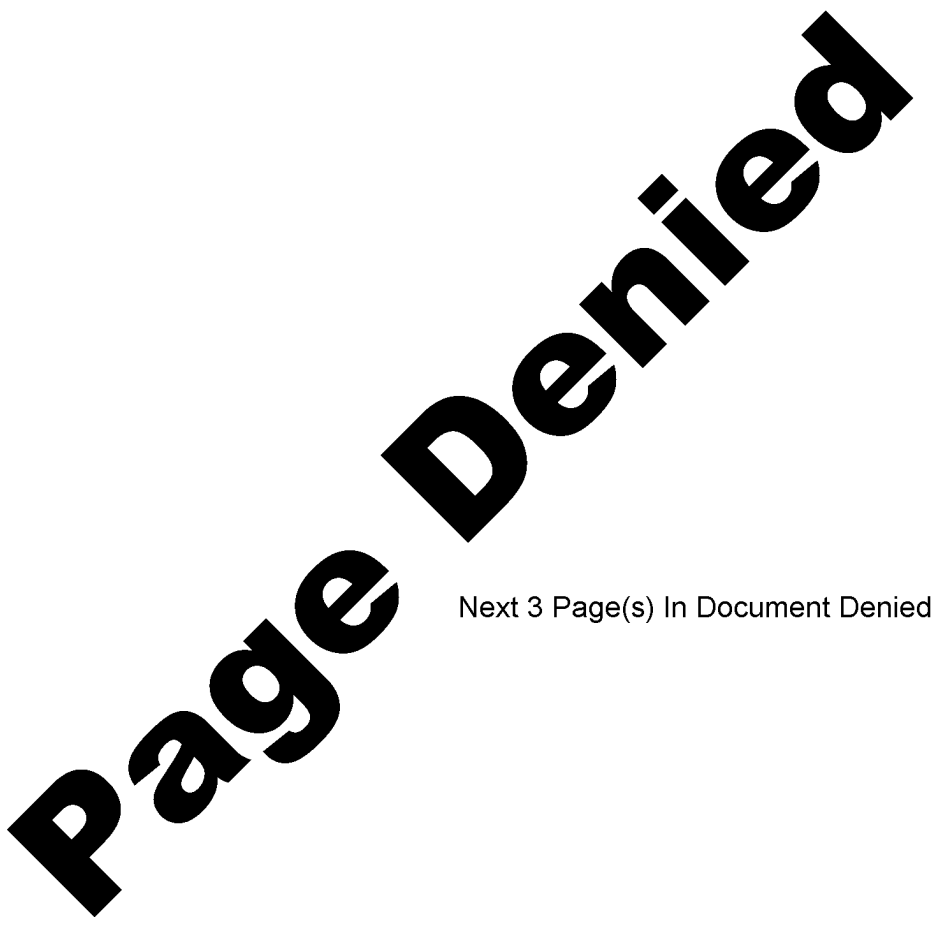

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Providing Security of Radio Communications when Moving Forward the Troops of a Reserve Front over Long Distances

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Radio is the primary means of communications and is capable of satisfying the most important requirements for troop control under the most difficult conditions. However, at the same time, radio communications is also the most important source of information for the enemy. Therefore, coming to the forefront, along with the need to provide reliability of radio communications, are problems concerning the security of radio communications. This security determines the viability of command posts, the degree to which radio communications are protected against enemy jamming, and, as a result -- the reliability of control.

In order to adopt a sound decision for the organization of radio communications and to establish the radio traffic routine, it is not enough to evaluate, from the qualitative aspect only, the capabilities of enemy radio reconnaissance. Such an evaluation, even of the same conditions, may often lead to completely opposite views, thereby influencing the routine adopted: from a complete prohibition of transmitting operations by radio means to a permission to operate without any restrictions whatsoever. In the first case, troop control is significantly impaired; and in the second case, the enemy is given the opportunity of obtaining important information, thereby adversely affecting the success of combat operations. Therefore special quantitative methods of evaluating enemy radio reconnaissance capabilities are required.

This article examines the methodology for quantitatively evaluating the security of shortwave radio communications and also lists some data which will allow the commands of operational formations and large units to adopt sound decisions concerning the employment of radio communications for control of the troops of a reserve front when moving them forward over a long distance. 50X1-HUM

The experience gained from a series of command-staff exercises and war games on maps conducted by the troops and by military academies over the

last five to six years shows that starting from the moment the troops of a border military district which is being deployed as a front are alerted, troop control must ensure the accomplishment of a number of difficult tasks. These include refinement of the tasks of the troops, control of the forward movement so as to accomplish it in the shortest possible time while retaining the combat effectiveness of the troops, and organizing commitment of the troops to action, etc.

Control of the troops of a reserve front when they are accomplishing assigned tasks, is carried out from the command post, the forward command post, and the rear control post. The complexity of troop control during this period is caused by the following: by the need to provide continuous control throughout the entire depth of the zone of movement and also after the troops are committed to action; by troop control difficulties which arise when control posts of a front, of armies, and of large units subordinate to the front are on the move; by the requirement to ensure the security -- from all types of enemy reconnaissance -- of both the movement forward of the troops and the areas where troops are concentrated and prepared for commitment to action; and lastly, by the diversity of the tasks of troop control.

In view of these difficulties, there has arisen a need, in addition, to detach operations groups of the front which can be deployed at the national border and major water obstacles and also in the final concentration area for the front troops.

The front command post and forward command post can be relocated by "leapfrogging": one of them is moved forward ahead of time with the calculation of leaving the troops, as a rule, a day's march behind. Control posts of the armies can be relocated by "successive displacement": the forward command post is moved forward and provides control from its position during the first day's march, the command post is moved with the troops of the army and then is set up in the area of that day's halt some distance away from the forward command post, and then the forward command post again is moved forward.

To provide control when the troops of the reserve front are moving forward, taking into account the above-indicated conditions of movement and deployment of control posts, it is possible to employ all means of communications: wire, radio-relay, messenger means, and radio.

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However, wire and radio-relay means organic to front and army communications units can be used only in areas of a day's halt. They are

essential for setting up a communications system during the commitment of the troops of the front to action and during the course of combat operations.

Wire channels of the state communications systems of the USSR and the people's democracies -- used primarily for communications between the organs of the Military Transportation Service, or the road traffic control areas, and the operations groups, and also between operations groups and the control posts of the front -- may be allocated to the front within its zone of movement. To provide wire communications with troop columns within the zone of movement it will be necessary to set up telephone points every 50 to 70 kilometers on each of the through routes. From 1,000 to 1,500 military communications personnel will be required at the front level to service these points and to staff the communications komendaturas of the stationary communications centers which are allocating the above-mentioned channels. In addition, a considerable quantity of personnel and cable means will be needed to lay connecting lines from stationary communications centers to telephone points and also to operations groups or to control posts of the front. It is extremely difficult to prepare a wire communications system in the short time period before the movement forward of the troops begins. If a system like this one is prepared beforehand, it can be damaged to a considerable degree when combat operations are initiated and too much time will be required to restore it.

Naturally, messenger means of communications will be widely used to control troops while they are moving forward. However, it is apparent that these means will not be able to make up for the lack of other communications means.

All of the enumerated factors lead one to the conclusion that in a complex operational situation radio is the primary means of communications for providing control of the troops of a reserve front when they are moving forward over long distances. During this period, radio communications must above all satisfy, along with other requirements, requirements for reliability and speed in the passage of information throughout the overall communications system. It is also very important to satisfy, in the interest of security of communications, radio camouflage requirements, which impose severe restrictions on the operation of radio communications means and result in decreased reliability in radio communications and reduced speed in transmitting information.

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Radio camouflage measures are determined with consideration of enemy radio reconnaissance capabilities. An analysis of these capabilities in

range of detection and in accuracy of location by direction finding of our radio and radio-relay sets, allows us to arrive at the following conclusions.

First, operation by reflected wave of R-102M2 and R-118M3 shortwave radio sets can be reconnoitered by the enemy throughout the entire depth of the front zone of movement; operation by ground wave (on frequencies below lowest applicable frequencies -- within the 1.5 to 2 megahertz band) can be reconnoitered from distances of 200 to 250 kilometers under ordinary conditions, and from distances of 300 to 400 kilometers when there are high-altitude nuclear bursts. Therefore transmissions by reflected wave should, as a rule, be forbidden or restricted and transmissions by ground wave should be permitted only with consideration for the operating range of enemy radio reconnaissance. Transmissions by shortwave radio sets on radio links using secure communications devices should, as a rule, be forbidden since this type of operation is a typical reconnaissance indicator of communications centers of operational formations. During a period when the troops are moving forward, radio sets should operate only in an amplitude-modulated, continuous-wave telegraphy mode.

Second, the enemy's range of assured reconnaissance of our R-104M and R-112 radio sets operating by ground wave with the four-meter whip antenna in the daytime is 30 to 40 kilometers and at night is 20 to 25 kilometers; when there are high-altitude nuclear bursts it averages 60 to 80 kilometers; and when operating by space wave it is from 200 to 1,000 kilometers (depending on the altitude of the F-layer). Despite this, the cited radio sets may be permitted to operate while front troops are moving forward since the enemy will not be able, on the basis of operational reconnaissance indicators, to determine their subordination from among the large number of radio sets of these types which are in the hands of front troops (2,500 to 3,000 sets). Furthermore, the operation of these radio sets will mask the activities of R-102M2 and R-118M3 radio sets since there are only several tens of them in front and army radio nets and they transmit in the same amplitude-modulated telegraphy mode as R-104M and R-112 sets.

Third, from the ground the enemy can have assured reconnaissance of our R-105 radio sets equipped with amplifier units and operating on ten-meter whip antennas, from a distance of 40 to 50 kilometers; assured reconnaissance of those operating on four-meter whip antennas, from a distance of 25 to 30 kilometers; and assured reconnaissance of those operating without amplifier units, from 15 to 18 kilometers away.

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The range of assured reconnaissance from the ground of R-401M and R-405 radio-relay sets operating on the main, side, and back lobes of their antenna radiation pattern amounts to 50 to 80 kilometers; and of the R-400M and R-404 sets operating on main lobes it is 60 to 70 kilometers, on side lobes it is 30 to 40 kilometers, and on back lobes it is 25 to 30 kilometers. The range at which the enemy can detect ultra-shortwave radio sets and lightweight radio-relay sets increases as reconnaissance equipment is borne higher up into the air. Under these conditions, however, when R-400M and R-404 sets are operating on the back lobes of their antenna radiation pattern, the range at which they can be detected does not increase for all practical purposes.

Thus, ultra-shortwave R-105 sets and all types of radio-relay sets can be allowed to operate when they are 100 to 150 kilometers or more away from the national border since they cannot be detected by enemy ground reconnaissance means. In addition, when these sets are reconnoitered by airborne means a considerable amount of time is required to carry out this reconnaissance, and linear errors in direction finding will amount to approximately plus or minus 30 kilometers. There is no doubt that transmissions by ultra-shortwave, low-power shortwave, and radio-relay radio sets are permissible only by strictly adhering to communications discipline and regulations for secure troop control.

Taking into consideration enemy reconnaissance capabilities, these are the basic recommendations which can be proposed concerning the use of ultra-shortwave, radio-relay, and low-power and medium-power shortwave radio sets operating by ground wave.

Reliability of radio communications when troops of a reserve front are moving forward will be achieved primarily in those instances where the operating range of radio sets matches the distance at which it is necessary, in the majority of cases, to maintain radio communications.

When the front command post and forward command post are relocated by "leapfrogging", the distance between one of these in position and the control posts of armies and large units subordinate to the front will fluctuate between 80 and 400 kilometers. The operating range of R-102M2 and R-118M3 radio sets operating by ground wave, a mode which can be used in accordance with the requirements for radio camouflage, is, in summer, 100 to 150 kilometers in the daytime and 60 to 90 kilometers at night; in winter, it is 110 to 180 kilometers in the daytime and 80 to 110 kilometers at night.

From the data presented it follows that the operating range of radio sets adhering to radio camouflage measures will not ensure that direct control over troop movement can be exercised from the command post or forward command post of the reserve front. This situation makes it necessary to use the communications systems of the organs of the road traffic control service and the Military Transportation Service, and of operations groups. However, it is necessary to keep in mind that even when time and means are available to set up a road traffic control service radio communications system, its transmitting capacity remains rather low. This feature may lead to intolerable delays in transmitting information about the progress of troop moves to control posts and in transmitting instructions to march column chiefs. Therefore, at present, a road traffic control radio communications system, when it is providing control over march columns, can be looked upon as merely an auxiliary system.

Efforts to use operations groups for direct control over troop columns, bypassing road traffic control service organs, run up against the same difficulties. When there are three front operations groups which have been separately dispatched ahead of time to the national border zone, to a large water obstacle, and to the final concentration area, the distances between them may range from 400 to 500 kilometers or more, and between any of them and the front troop columns the distances may range from 250 to 300 kilometers, which also prevents continuous shortwave radio communications by ground wave.

In the future, when not only operations groups but also auxiliary communications centers of the General Staff and communications centers of the state communications system are used to control troops of a reserve front moving forward, a system of base radio communications centers, operating by ground wave, may be established to maintain communications with control posts of the front and of armies and troop columns. The capability of operating base radio communications centers by ground wave can be achieved by having six to eight base radio communications centers in the zone of movement, when the distance between centers is 200 to 500 kilometers and the distance from troop columns and the control posts of the armies to the nearest base radio communications center is 100 to 150 kilometers.

At the given distances it is also possible to use ultra-shortwave radio communications. For this purpose it is necessary to have R-972 helicopter-borne communications centers at the base radio communications centers. When a helicopter rises to an altitude of 1,500 to 2,000 meters, the R-105 radio sets found in these helicopters can provide reliable radio

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communications with ground sets of the same type at distances from 150 to 180 kilometers. When the communications range is 100 kilometers, it will suffice to have the helicopter go up to an elevation of 400 meters. Enemy ground radio reconnaissance can detect the operation of helicopter-borne radio sets, but at ranges of 80 to 100 kilometers and more the operation of ground radio sets will not be detected.

However, it is necessary to keep in mind that it is not always possible to ensure the security of front shortwave radio communications by utilizing ground waves alone. Thus, in wintertime, especially at night, the lowest applicable frequencies are those below 1.5 megahertz, i.e., those lying outside the frequency band limits of R-102M2 and R-118M3 radio sets. In this case the use of whip antennas merely degrades the quality of communications, and the radio sets will be reconnoitered by the enemy.

In this connection there arises the necessity for a quantitative evaluation of enemy capabilities to reconnoiter the shortwave radio sets located at the control posts of the front, the armies, and operations groups, and operating by reflected wave. This evaluation will vary in accordance with the operating routines of the radio sets and the volume of information the radio sets transmit.

When evaluating the security of shortwave radio sets operating by reflected wave, the range and the accuracy of direction finding of enemy radio reconnaissance have to be considered, as do also the presence of reconnaissance indicators and time parameters (duration) of the emissions of our own radio sets.

When developing methods of evaluating the security of the operation of the shortwave radio communications of the operational level of control, we used the following basic data:

-- to conduct radio reconnaissance the enemy uses a shortwave radio reconnaissance site, drawn from the complement of an Army Security Agency group and located 40 to 60 kilometers away from the national border or the line of contact of the opposing sides; a similar site may be set up 200 to 250 kilometers away in the second echelon. These sites obtain direction-finding data upon request or provide synchronous direction finding. The shortwave radio reconnaissance site is made up of 60 to 75 search and tracking posts and up to 15 receiver-indicator direction-finding sets borne by receiver-indicator vehicles of radio reconnaissance;

-- in the operation of R-102M2, R-118M3, and R-103M front troop radio sets, at distances of up to 300 to 500 kilometers the average width of the reflected wave band segment lying between lowest applicable frequency and

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maximum applicable frequency ranges from 2 to 8 megahertz;

-- to hamper enemy radio reconnaissance efforts all radio sets are to operate in the amplitude-modulated, continuous-wave telegraphy mode, but the range of the radio reconnaissance covers the entire zone of movement of the front troops;

-- field direction finders have a built-in technical angle error in direction finding that is on the order of $\Delta_T^\circ = \pm 1 - 2^\circ$, and a practical operating angle error that averages $\Delta_\Pi^\circ = (1.5 - 2)\Delta_T^\circ$; and the magnitude of the linear error in direction finding (in kilometers) can be determined approximately by the formula $L = 0.042R$ (where R = radio reconnaissance range in kilometers);

-- the durations of single emissions by army and front radio sets during the period when the troops are moving forward were established as equaling 1 to 2, 2 to 4, 3 to 9, 6 to 12, and 12 to 24 minutes; the average duration of the main bulk of emissions was 4 to 6 minutes;

-- allowance was made for band loading by distant emissions in the radio frequency range and also by the emissions of sets being reconnoitered, enemy radio sets, and radio sets ahead of the active front.

We developed a model of the shortwave radio reconnaissance site in operation during the search period when there is a relatively reduced load on each radio reconnaissance post and the duration of emission by the radio sets being reconnoitered was long enough to permit the enemy to carry out radio reconnaissance by the "traverse" method (monitoring a limited number of detected frequencies).

Data obtained from the model will permit solving practical problems in evaluating the security of radio communications after an officer of a communications directorate, section, or unit, who is making calculations, becomes convinced that a particular radio set can be detected by enemy radio reconnaissance and located with sufficient accuracy by direction finding. Such problems include the following.

Determination of the probability that a radio set operating by single transmissions can be reconnoitered (P_M). An approximate determination can be made by using the formula

$$P_M = \frac{t_r - \Delta T}{T_{np}} \cdot p \qquad (1)$$

(when $t_r < T_{np}$),

where t_r is the average duration of a single emission by the radio set;

ΔT is the average time necessary to identify a radio set and locate it by direction finding;

P is the operating reliability of the direction-finding net;

$T_{пр}$ is the average retuning time for a search post receiver within its assigned segment of the frequency band.

$$\Delta T = t_1 + t_2 + t_3 + \Delta t \ ,$$

where t_1 is the average time spent by the radio reconnaissance operator in preliminary monitoring and identification of the set (determining the type of operation of the set);

t_2 is the average waiting time for the direction finder;

t_3 is the average time spent by the local direction finder in fixing the set by direction finding;

$t_3 + \Delta t$ is the average time spent by the direction-finding net in fixing the set by direction finding.

The value of ΔT, obtained on an electronic computer by modeling the enemy's radio reconnaissance system, amounts to 1.5 minutes for synchronous systems and to two minutes for non-synchronous systems. The magnitude of $T_{пр}$ was also determined by modeling on an electronic computer and amounts to 18 minutes approximately. The given data may be used for approximate calculations by formula (1).

The probability that a radio station can be reconnoitered is determined by formula (1) by assuming that the instants of entry of the enemy's reconnoitering receiver onto frequency [1] and the instants when our station begins to operate on this frequency are not correlated random events, but that the process in its entirety is fixed. These conditions are fulfilled if the radio set is transmitting for the first time, or after it shifts radio operating data, and does not have characteristic reconnaissance indicators.

Determination of the number N of periods of transmission over which a radio set can be reconnoitered with probability d. The magnitude of N can be calculated by the formula

$$N = \frac{\log (1-d)}{\log (1-P_M)} \ . \qquad (2)$$

For convenience in calculations a table may be drawn up to permit determining N according to the values assigned to d and P_M.

Determination of the time required to reconnoiter a radio set with a prescribed reliability -- a reliability obtainable over N periods of transmission -- can be done by the formula

$$T_d = N\ (t_r + t_5)\ , \qquad (3)$$

where t_5 is the time interval between periods of transmission.

When the values of security of communications and the number of periods of transmission are given, the duration of a single emission of a radio set can be determined by the formula

$$t_r = \frac{(1 - \sqrt[N]{1 - d})\ T_{пр}}{p} + \Delta T. \qquad (4)$$

When the operating routine is given for each of the M radio sets of the communications center, and there is a requirement to determine the probability $P_{M\ (m)}$ that the enemy will not reconnoiter during the time of operation more than m radio sets out of the M sets and will not obtain a reconnaissance indicator of a command post, then Table 1 is used to permit determining $P_{M\ (m)}$ in accordance with the calculated value of

$$X = \frac{m - Md}{\sqrt{Md\ (1 - d)}}\ .$$

Table 1 also permits solving other problems in calculating the security of a radio communications system.

As a result of solving the above-mentioned problems in evaluating the security of front and army shortwave radio communications used to control the troops of a reserve front moving forward over a long distance, one can then offer the following practical recommendations:

-- to evaluate the security of radio communications when an order or report with a specific number of text groups and priority level must be transmitted without fail despite the fact that it is a period in which the

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use of radio communications is restricted in accordance with the conditions of the situation;

-- to calculate the amount of information, coming in from staff sections, which can be transmitted during a specific time period over shortwave radio channels, when the level of radio communications security has been strictly prescribed due to the requirements of radio camouflage. Under these conditions non-priority information can be transmitted on shortwave radio channels only upon instructions from the chief of staff;

-- to establish and then report to the chief of staff the periods during which a given volume of non-priority information can be transmitted to large units (units), allowing for the prescribed security and the status of radio communications;

-- to evaluate the security of the operation of radio groups at communications centers of control posts of operational formations when radio means are operating unrestrictedly or to make calculations to determine the restrictions to be placed on radio communications loading with a given degree of security of the radio communications of the control posts and with consideration of the time the latter are to be in a particular area;

-- to calculate how effectively enemy radio reconnaissance has been deceived by the operation of communications means at dummy control posts deployed in accordance with the plan of operational camouflage;

-- to calculate the probability of enemy reconnaissance detecting our radio communications and jamming them at the start of combat operations, and also to evaluate our capabilites to jam enemy radio means.

To solve the problem of quantitatively evaluating the security of radio communications, a problem which is very important not only when front troops are moving forward but also when troops are engaged in all types of routine and combat activities, the authors of this article have sought to apply the statistical sampling method using an electronic computer. The results of this research should undergo verification in practice and further improvement from the standpoint of refining the systems and their methods of functioning, and also refining the initial data under various situational conditions.

Table 1 values of P_M (m) as a function of X

X	P_M (m)	X	P_M (m)	X	P_M (m)
-2.5	0.006	-0.8	0.212	0.9	0.82
-2.4	0.008	-0.7	0.242	1	0.84
-2.3	0.011	-0.6	0.274	1.1	0.864
-2.2	0.014	-0.5	0.308	1.2	0.885
-2.1	0.018	-0.4	0.345	1.3	0.9
-2	0.023	-0.3	0.382	1.4	0.92
-1.9	0.029	-0.2	0.421	1.5	0.93
-1.8	0.036	-0.1	0.46	1.6	0.945
-1.7	0.045	0.0	0.5	1.7	0.955
-1.6	0.055	0.1	0.54	1.8	0.964
-1.5	0.067	0.2	0.58	1.9	0.97
-1.4	0.081	0.3	0.62	2	0.977
-1.3	0.097	0.4	0.655	2.1	0.982
-1.2	0.115	0.5	0.69	2.2	0.986
-1.1	0.136	0.6	0.72	2.3	0.989
-1	0.159	0.7	0.73	2.4	0.992
-0.9	0.184	0.8	0.79		

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